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Behavior of Financial Markets Efficiency During the Financial Market Crisis: 2007-2009

H. R. Mynhardt and Alex Plastun and Inna Makarenko

University of South Africa, National Bank of Ukraine - Ukrainian Academy of Banking, National Bank of Ukraine - Ukrainian Academy of Banking

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BEHAVIOR OF FINANCIAL MARKETS EFFICIENCY DURING THE FINANCIAL MARKET CRISIS: 2007 – 2009

This paper examines the behavior of financial markets efficiency during the recent financial market crisis. Using the Hurst exponent as a criterion of market efficiency we show that level of market efficiency is different for pre-crisis and crisis periods. We also classify financial markets of different countries by the level of their efficiency and reaffirm that financial markets of developed countries are more efficient than the developing ones. Based on Ukrainian financial market analysis we show the reasons of inefficiency of financial markets and provide some recommendations on their solution and thus improving the efficiency.

Keywords: *Persistence, R/S Analysis, Hurst exponent, Fractal market Hypothesis, efficiency of financial market.*

Corresponding author:
Prof. Ronald H Mynhardt
**University of South Africa*
PO Box 392, Unisa 0003
Tel: +27 12 429 4927
mynharh@unisa.ac.za
and
Assos. Prof. Alexey Plastun
** Ukrainian academy of banking*
of the National bank of Ukraine
57, Petropavlivska Str.,
40000, Sumy, Ukraine
Tel. +350509339027
o.plastun@gmail.com
and
Assist. Prof. Inna Makarenko
** Ukrainian academy of banking*
of the National bank of Ukraine
57, Petropavlivska Str.,
40000, Sumy, Ukraine
Tel. +350669356016
i_o_makarenko@ukr.net

1. Introduction

In time of the financial markets reforms in response to the global financial crisis consequences the process of rethinking of the theoretical concepts explaining the behavior of these markets is activated.

The Efficient Market Hypothesis (EMH), proposed by Fama (1970), has for a long time occupied the leading position in the explanation of the financial markets behavior. Even today it is a cornerstone of modern finance theory and the majority of methodological approaches to the valuation of financial instruments.

However, history shows that the EMH is not always confirmed (see Jensen (1978) and Malkiel (2003) for details) and the level of market efficiency differs for different countries (see Lo and MacKinlay (1988), Urrutia (1995), Huang, B. (1995), Hassan, Shah and Abdullah (2007), Borges (2008) and many others). In addition, during the financial crisis of 2007-2009, market participants have suffered the greatest losses in the markets that are traditionally considered to be effective (see Ball (2009)). Similar examples have been observed earlier during other crises.

These and many other examples of inconsistency of the EMH have led to the emergence and development of alternative concepts that explain the behavior of financial markets: behavioral finance (Kahneman and Tversky (1979)), adaptive market hypothesis (first mentioned by Lo (2004)), fractal market hypothesis (FMH - see Mandelbrot, 1972, Peters, 1994) and many others.

An important role in the process of rethinking is the FMH which is seen as an alternative to the traditional EMH. The use of key categories of this hypothesis such as market persistence, noise of index series, fractality, and some specific indicators showing the state of the market such as: the Hurst exponent and fractal dimension is an important way for the formation of a new non-linear methods of modeling the behavior of the financial market during the crisis and for crises prognoses in the future. Methodology of FMH also helps to measure the level of market efficiency.

Despite a considerable amount of research already conducted on measuring the market efficiency the problem is not solved yet (Peters (1994), Daw et al. (2003), Grech and Mazur (2004), Bassler et al. (2006), McCauley et al. (2007) and many others). There is no common methodology, results differ, some aspects are discussed insufficiently etc. For example, behavior of market efficiency during crisis in general and from the position of differences between countries is not clear even nowadays.

This paper aims to expand the results of financial markets efficiency metrics using data from different countries during different economic phases (normal and crisis). The purpose of this study is to confirm/reject hypothesis of instability of financial markets efficiency in different economic conditions.

We analyze data from different financial markets divided into two groups: developed (U.S., Japan, UK, EU) and developing (China, India, Brazil, Russia and Ukraine). As examples of concrete financial markets we choose national stock markets (as a concrete indicator stock index of the country was used), foreign exchange market (the official exchange rate fluctuations of the national currency). This allows us to get general (common) result for different countries and financial markets based on same methodology. To measure the level of market efficiency we used Hurst exponent calculated with R/S analysis. Hurst exponent close to 0.5 evidences in favor of efficiency of the market, the more Hurst exponent differs from 0.5 the less effective the market is.

The paper is organized as follows: A review of the existing literature on Fractal Market hypothesis. A section that provides the methodology followed in the study. Next follows a section that presents the results and key findings of the study. A separate section is devoted to the problems of market efficiency increasing. Last there a section on the conclusions and summary of the paper.

2. Analysis of key theoretical concepts explaining financial market behavior

The EMH used to occupy the leading position in the explanation of the financial markets behavior; it remained dominant for a long time and has been a cornerstone of modern finance theory and the majority of methodological approaches to the valuation of financial instruments.

EMH, proposed by Fama (1970), provides that a market in which prices reflect all available information is effective. According to this hypothesis, modern financial markets are informational transparent and correspond to the notion of efficient markets.

It should also be noted that the EMH describes the ideal state of the market, is easy to interpret and uses a convenient and apprehensible mathematical approaches. It is usually relevant on a variety of financial markets in the absence of financial crises. Furthermore, numerous models of evaluation of financial instruments and of their portfolios are built considering that this hypothesis is confirmed (for example CAPM - J. Treynor (1962), W. Sharpe (1964), J. Lintner (1965) and J. Mossin (1966); Black–Scholes options pricing model, F. Black, M. Scholes (1973)).

However, experience shows that the EMH is not always confirmed. In favor of its failure indicates the presence of numerous market anomalies: the excess volatility puzzle, time effects, positive serial correlation of price growth in the period up to six months and negative - in periods of three to eight years for the market indexes, a number of calendar anomalies (effect of months, effect of the year, effect of the day, effect of the week, effect of the full moon, the effect of the time of the year) etc (see Damodaran A., 2002 for details).

In addition, during the financial crisis of 2007-2009, market participants have suffered the greatest losses in the markets that are traditionally considered to be effective and with an extraordinary opportunity of a crisis from the perspective of the EMH, the markets of developed countries in particular. The crisis in these markets has become a source of propagation of shocks in the financial markets of other countries and led to a general destabilization of the world financial and economic systems.

Similar examples have been observed earlier. For example, in 1997, the Dow Jones fell in a single day by 7.7 % (the probability of such an event - one to 50 billions). In July 2002, the index dipped three times during seven trading days (the probability of this event - one chance in four trillion). October 19, 1987 (the famous «Black Monday»), the index fell by 29.2 %. This is probably one of the worst trading days in the last century. According to the standard models of financial theory such event could occur less than at one of the 1050 cases (Hudson, Richard L.; Mandelbrot, Benoît B., 2004)).

These and many other examples of inconsistency of the EMH have led to the emergence and development of alternative concepts that explain the behavior of financial markets: behavioral finance, adaptive market hypothesis (AMH), fractal market hypothesis (FMH) and many others.

According to the theory of behavioral finance efficient financial markets with equilibrium prices would not be attractive to their participants. Proceedings of the Nobel laureates in economic studies of human behavior – Kahneman and Tversky (1979) – initiated the concept of alternative finance, based on a statement that the behavior of a market is not always determined correctly and predictably, it depends on the subjective psychological factors.

The AMH was first mentioned by Lo (2004), who proves the existence of connection between the economy and sociobiological theories of evolution. This theory is some sort of compromise between the rational expectations theory and behavioral finance.

Quite often the EMH and AMH are opposed to one of the hypotheses of fractal geometry – FMH, which proposes more complex stochastic processes to be the basis of the understanding of the market essence and behavior.

Mandelbrot (1969, 1971, 1972) was the first who fixed the fact of market persistence – the ability of the state to exist longer than the process that created it. According to his results financial markets have long-memory.

Further development of the Mandelbrots’ ideas was done by Greene and Fielitz (1977). They proved presence of long-term dependence in prices of the stocks in the NY stock exchange. Booth, Kaen, and Koveos (1982) also confirmed that some financial data has long memory. Helms et al. (1984) as an object of analysis chose prices on futures and also proved the fact of market persistence.

Ideas of FMH were actively popularized by Peters (1991, 1994).

Further methodology of market persistence estimation was improved and tested on financial data of different countries, periods and time intervals.

For example, Lo (1991) substantiated the necessity of short-term memory incorporation in estimations of long-term memory. According to his results quite often long-term memory detection can be explained by mistakes in methodology caused by the presence of short-memory. Lo (1991) and other authors, who used his methodology (Fung and Lo (1993), Cheung and Lai (1993), Crato (1994)) proved the fact of the absence of long-term memory on the main financial markets.

Sufficient number of researches devoted to the problem of market persistence and long-term memory, different methodology and absence of unified one, cause further development of this problematic, especially in the context of long-term memory identification and methodology of market persistence estimation.

Important contribution in research of financial markets persistence was done by Los (2003), who analyzed the existing methodology quite carefully. According to Los (2003), one of the key indicators of the level of persistence is so called Hurst exponent. Hurst exponent was created by hydrologist Hurst (1951).

Traditional methodology of Hurst exponent estimation includes the following methods:

- rescaled range analysis (R/S analysis);
- generalized Hurst exponent approach (GHE),
- stabilogram diffusion analysis (SDA);
- detrended fluctuation analysis (DFA);
- multifractal generalization (MF-DFA);
- others.

Modern methodology of markets persistence estimation is quite diverse that is why it is important to choose appropriate one for the financial data analysis.

Some of researches were devoted to the theoretical foundations of certain methodology. In such works as an object of analysis acted not real financial data, but data artificially generated by certain algorithm. As a rule, to generate data set Monte-Carlo method was used.

Results are presented in **Appendix A**.

Results of artificially generated time-series analysis are mixed. In general advantage is given to detrended fluctuation analysis (DFA) (Weron, R. (2002), Grech and Mazur, (2005)).

Financial data time-series and their persistence were analyzed very thorough in case of different types of financial markets: stock markets (Greene and Fielitz (1977),Lo (1991), Cheung and Lai (1995), Jacobsen (1995), Opong et al. (1999), McKenzie, 2001, Costa and Vasconcelos, 2003, Los (2006), Onali and Goddard (2009), commodities markets (Cheung and Lai (1993); Barkoulas, Labys, and Onochie (1997), Crato and Ray (1999), Alvarez-Ramirez et al. (2002), Serletis and Rosenberg (2007)), FOREX (Mulligan (2000), Kim and Yoon (2004), Da Silva et al. (2007)).

More detailed results for different types of financial markets are presented in **Appendix B**.

Analysis shows that the most common object of research is stock market. As an instrument of analysis leading stock market index of the country is used.

Empirical results are mixed. This can be explained by the differences in methodology and different periods and objects of analysis.

Results differ from the statement of the presence and statistical significance of the long-term memory of the market (Greene and Fielitz (1977), Peters (1991) and Peters (1994), Hja Su, LinYang (2003), Lento (2009), Onali and Goddard (2010)) to conclusions about random nature of price fluctuations and absence of the long-term memory of the market Lo (1991), Jacobsen (1995), Berg and Lyhagen (1996), Crato and Ray (1999), Batten et al. (2003), Serletis and Rosenberg (2009)).

An important result of the analyzed researches is changing behavior of the Hurst exponent. I.e. value of H is not a fixed constant, but changes in time (Corazza and Malliaris (2002), Glenn (2007) and others).

Hurst exponent also can be used to rank the efficiency of markets (Cajueiro and Tabak (2004, 2005)) - the higher the Hurst exponent is, the lower the efficiency of the market is.

From the position of current research quite important are works by Grech and Mazur (2004) and Grech and Pamula (2008), who investigate a connection between the Hurst exponent and market crashes.

Thereby R/S analysis is one of the most popular methodologies of the financial markets' persistence estimation.

It is worth noting that the efficiency (the equilibrium state of the market) is also explained as a special case of this hypothesis, and the calculation of indicators that could be evidence in support of the existence of long-term memory (persistence) in the market and predict it is an urgent task.

Despite the wide range of existing researches, heterogeneity of their results, lack of researches devoted to dynamic analysis of market persistence especially on the different stages of the economic cycle cause the necessity of further researches in this sphere.

So research of the market persistence depending on the state of economic system is an important scientific problem.

3. Research methodology

The method of R/S analysis was originally applied by Hurst (1951) in hydrological research and was improved by Mandelbrot (1972), Peters (1991, 1994) and other researchers of financial markets fractal nature. Compared with other approaches the method of R/S analysis is relatively simple, suitable for programming and visual interpretation.

For each sub-period range R (the difference between the maximum and minimum index within the sub-period), the standard deviation S and their average ratio are calculated. The length of the sub-period is increased and the calculation repeated until the size of the sub-period is equal to that of the original series. As a result, each sub-period is determined by the average value of R/S. The least square method is applied to these values and a regression is run, obtaining an estimate of the angle of the regression line. This estimate is a measure of the Hurst exponent, which is an indicator of market persistence (see Gachkov (2009) for more details and explanations).

To estimate persistence during the financial crisis we used the dynamic Hurst exponent calculation. We calculate Hurst exponent for different data windows. We checked different window sizes and found on the basis of the behavior of the Hurst exponent that size 300 (close to one calendar year) is the most appropriate: for narrower windows its volatility increases dramatically, whilst for wider ones it is almost constant, and therefore the dynamics are not apparent.

Having calculated the first value of the Hurst exponent (for example, Hurst exponent for the date 13.07.2007 is calculated on the data for the period from 21.04.2005 till 13.07.2007), each of the following ones is obtained by shifting forward the “data window”. The chosen size of the shift is 10, which provides a sufficient number of estimates to analyze the behavior of the Hurst exponent. Therefore the second value is calculated for 27.07.2006 and characterizes the market over the period 10.05.2005 till 27.07.2006, and so on. As a result we obtain a variety of control points (Hurst exponent estimates) for different sub-samples characterized by various degrees of persistence over the analyzed period.

Hurst exponent can be defined on the interval [0, 1], and is calculated within the following limits:

- $0 \leq H < 0{,}5$ – data is fractal, FMH is confirmed, «heavy tails» of distribution, antipersistent series, negative correlation in instruments value changes, pink noise with frequent changes in direction of price movement, trading in the market is more risky for an individual participant;
- $H = 0{,}5$ – data is random, EMH is confirmed, movement of asset prices is an example of the random Brownian motion (Wiener process), time series are normally distributed, lack of correlation in changes in value of assets (memory of series), white noise of independent random process, traders cannot «beat» the market with the use of any trading strategy
- $0{,}5 < H \leq 1$ – data is fractal, FMH is confirmed, «heavy tails» of distribution, persistent series, positive correlation within changes in the value of assets, black noise, trend is present in the market

Essential aspects of the practical calculation of the Hurst exponent are:

- The choice of market indicators – time series for the analysis;
- The choice of the study period and the interval of the graphic of selected indicator ;
- Interpretation of results for the period of 1990-2007 and during the last financial crisis of 2007-2010.

The selection of market indicators in the form of an index series was carried out by us for the world's biggest developed financial markets and emerging markets. Among the developed ones the U.S., Japan, UK, EU markets have been traditionally chosen, among developing markets – China, India, Brazil, Russia and Ukraine.

The range of tools for analysis was determined by the market under investigation. For example, during the study of the stock market of each of these countries its benchmark index was selected, in the study of the foreign exchange market– the official exchange rate fluctuations of the national currency of each country to the U.S. dollar.

To illustrate the importance of both hypotheses – the EMH and FMH to explain the behavior of financial markets at different stages of their development it is important to choose the period of the study. Thus, to compare the data one should make the calculations for a certain period of operation of the financial markets in general as well as for the period of the crisis in them.

Therefore we propose to carry out calculations on separate financial markets for the earliest possible period starting from 1990s, given the homogeneity of dates.

What is concerned about the choice of the interval graphs of index fluctuations (5, 30, 60 min.), 1 day, a week, a month – within the selected periods of research we will focus on a range of 1 day, because, in our opinion, the price fluctuations of this dimension meet the objectives of the analysis better – greater frequency generates significant fluctuations of fractals, at a lower frequency analytical value of data is lost.

4. Findings

First we analyze the persistence of financial markets before the global financial crisis. The period of analysis was 1990-2007. The results are presented in Table 2.

Table 2: Hurst exponent characterizing the individual financial markets of developed countries and developing countries in 1990-2007

Country		Stock market		Foreign exchange market	
		Index	Hurst exponent	Currency	Hurst exponent
Developed countries	USA	DowJones	0,508	CHF	0,534
	Japan	NIKKEI	0,556	JPY	0,572
	Great Britain	FTSE	0,531	GBP[1]	0,530
	EU	DAX	0,565	EUR	0,562
Developin	China	SSEC[2]	0,609	YUAN[3]	0,46
	Brazil	Bovespa[4]	0,647	BRL[5]	0,634

[1]Quotes from 1991 г.
[2]Quotes from 1997
[3]Quotes from 1997
[4]Quotes from 1993
[5]Quotes from 1995

	India	BSE SenSex[6]	0,621	INR[7]	0,596
	Russia	RTS[8]	0,601	RUB[9]	0,631
	Ukraine	PFTS	0,665	UAH[10]	0,464
		UX	0,667		

To ease the interpretation of results we provide their graphical representation which is shown in Fig.1. According to the figure two polar groups of markets and countries are clearly observed: developed countries with high GDP per capita and the Hurst exponent close to 0.5, which indicates the adequacy of the EMH, and developing countries with low GDP per capita and the Hurst exponent tending to 1, indicating the adequacy of FMH.

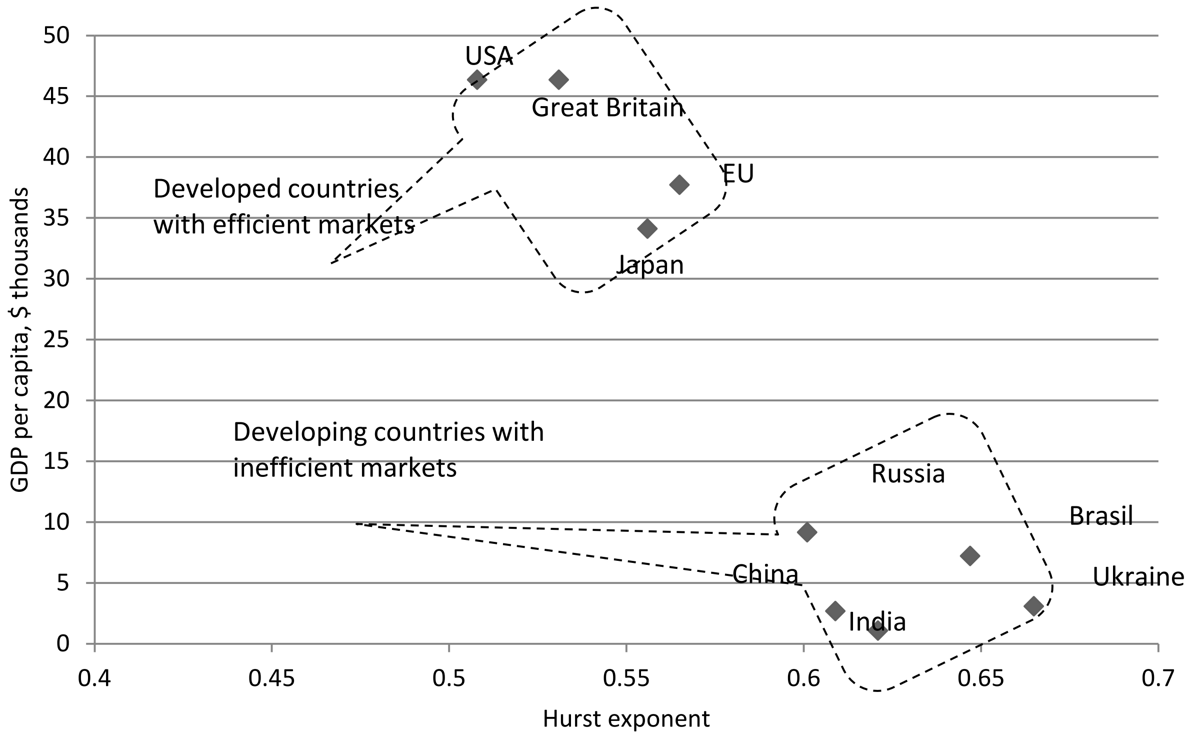

Fig.1 - The ratio of the Hurst exponent on the stock market with a GDP per capita of developed and developing countries

Similar conclusions can be made with analyzing the foreign exchange markets of these countries. It should be noted that the stock and foreign exchange markets of developing countries in support of the FMH are high volatility, attractive for speculates, movement of asset prices in these markets has trending nature, which also indirectly indicates an imbalance of investment horizons of the participants of these markets. We emphasize that the Hurst exponent for these markets demonstrates the presence of long-term memory (persistence) in the analyzed time series.

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[6] Quotes from 1997
[7] Quotes from 1991
[8] Quotes from 1995
[9] Quotes from 2007
[10] Quotes from 1997

The next step was to analyze the behavior of the persistence of global markets during the global financial crisis. To do this we used dynamic Hurst exponent calculation. The period of analysis was 2007-2010. This period covers both the period of «bubble» inflation and the relative market overheating, which created the preconditions for the crisis – 2007, the peak of the crisis at the end of 2008 and in 2009 and the attenuation of the crisis – 2009 -2010.

To demonstrate the example of dynamic analysis of Hurst exponent we build the graph of the behavior of Hurst exponent for PFTS index (Ukraine stock exchange index) during financial crisis. It is presented in Fig. 2.

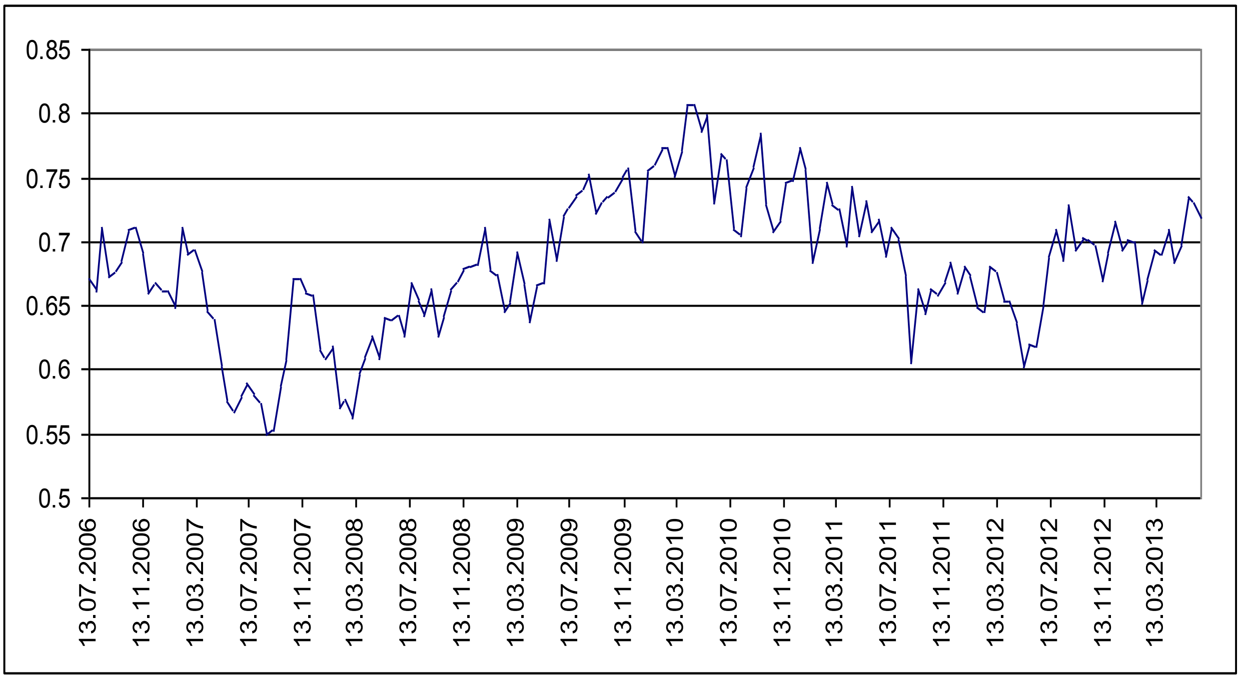

Fig. 2 - Dynamics of Hurst exponent during 2006-2013 (calculated on PFTS data with “data window” = 300, shift = 10)

Using such methodology we calculate the dynamic of Hurst exponent for different financial markets in different countries. As we are interested in estimations of Hurst exponent volatility (measure of persistent changes) we choose maximum and minimum values of Hurst exponent during analyzed period. Results are presented in Table 3.

Table 3: Hurst exponent characterizing the individual financial markets of developed and developing countries in 2007-2010

Contry		Stock market		Currency market	
		Hurst exponent	Currency	Hurst exponent	Currency
Developed countries	USA	DowJones	Max=0.63 Min=0.49	CHF	Max=0.64 Min=0.51
	Japan	NIKKEI	Max=0.61 Min=0.49	JPY	Max=0.64 Min=0.47
	Great Britain	FTSE	Max=0.59 Min=0.50	GBP	Max=0.66 Min=0.51
	EU	DAX	Max=0.62 Min=0.45	EUR	Max=0.67 Min=0.53

Developing countries	China	SSEC	Max=0.61 Min=0.45	YUAN	Max=0.60 Min=0.44
	Brasil	Bovespa	Max=0.61 Min=0.51	BRL	Max=0.69 Min=0.48
	India	BSE SenSex	Max=0.62 Min=0.54	INR	Max=0.67 Min=0.51
	Russia	RTS	Max=0.65 Min=0.57	RUB	Max=0.64 Min=0.52
	Ukraine	PFTS	Max=0.82 Min=0.61	UAH	Max=0.62 Min=0.40
		UX	Max=0.63 Min=0.49		

Graphical interpretation of the results (Figures3 and 4) shows first of all that during the global financial crisis the EMH was not performed neither for emerging markets nor for developed.

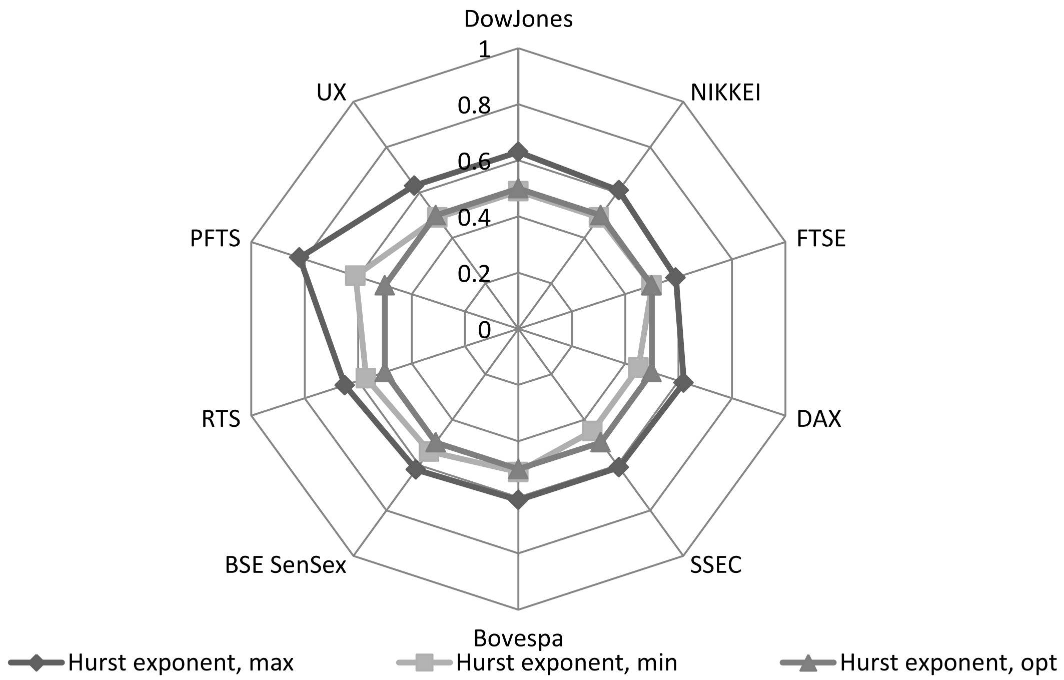

Fig. 4 - Hurst exponent on the stock markets of developed and developing countries during the crisis

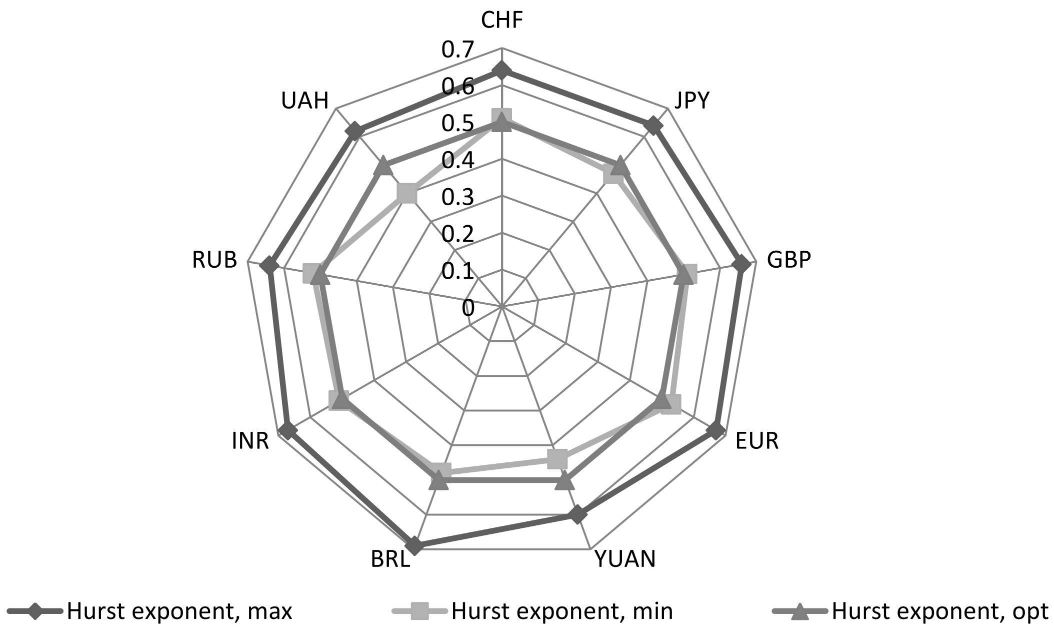

Fig. 5 - Hurst exponent on the currency markets of developed and developing countries during the crisis

Fluctuations in the maximum and minimum indexes of the Hurst exponent in the stock and foreign exchange markets of the countries under analyses indicated the presence in the time series of these markets the properties of the persistence and antipersistence, besides in most cases markets showed high volatility and riskiness of individual trading strategies. This fact, in its turn, indicates that FMH was fully performed during the crisis.

The results of calculation of the Hurst exponent are fully consistent with the actual data. Thus, the maximum value of the Hurst exponent in the crisis period is observed for the Ukrainian stock market (stock exchange PFTS)– 0.82. In this case, the stock market decline of the country was also a record in comparison to developed markets as well as to developing – in 2008 it was 80 % of the prior period.

At the same time, other developing markets, the Hurst exponent for which is the evidence of the violent crisis phenomena, in 2008 compared to 2007 also show a significant drop: Brazil – 56.2 %, India – 64.6 %, China – 70, 9%, Russia – 71.2 % (see Mirkin, 2008).

Concerning the foreign exchange market, one of the leaders of the fall during the global financial crisis among the currencies of the BRIC became Brazilian real. According to the Bank for International Settlements, decline in the real effective exchange rate of the currency in 2008 compared to 2007 was 20 ppt, which is quite significant against the background of a stable trend since 2002 of strengthening this currency (see Ivanova, 2013). These findings are supported by our calculations – for the time series characterizing the dynamics of the Brazilian real the Hurst exponent constitutes 0.69.

The same conclusions about the implementation of the FMH for developed countries during the crisis can be made based on the indexes of Hurst indicators confirmed by the real dynamics of the analyzed indexes. Thus, the decline in developed markets in 2008 (stock index on November 26, 2008 compared to December 31, 2007, in dollar terms) was: USA – 34.2%, Japan – 36.9%, UK – 50.2%; France – 50.2%, Germany – 50.2%, Italy – 54.5% (see Mirkin, 2008).

Achieved results may act as a basis for the formation of trading strategies for the participants of the market. The value of the Hurst exponent allows making conclusions about the current level of market efficiency. The inefficiency of the market signals about the possibility of profitable trading. For example high persistence allows using trend-oriented trading strategies. Plus low efficiency of the financial markets activates numerous market anomalies. Trading strategies, based on anomalies, also may become the source of speculative profits. So the Hurst exponent by the R/S analysis can certainly be useful to create customized strategies for traders in financial markets.

Concerning the volatility of the Hurst exponent in times of crisis, in this context we consider it necessary to emphasize that the Hurst exponent can be used as a tool to predict the expectations of investors in general and on the macro level. Hurst exponent can act as a kind of fear index, which reflects the current market conditions, the direction of its future development and the appropriate level of uncertainty (volatility), and investor sentiment. The growth of the Hurst exponent shows continuous market inefficiencies, and conversely, the lower the exponent is – the more efficient the market gets.

As we can see, methodology of FMH can be useful in market efficiency metrics.

5. Improving the market efficiency: Case of Ukraine

As we can see, financial markets can be quite unstable from the position of their efficiency. Nevertheless it is clear that efficient state is evolutional norm for the financial markets (see results of developed countries for pre-crisis period). That is why it is quite important to find out how to improve the efficiency of the financial markets.

Based on result of analysis we can point out, that Ukrainian financial market is the most ineffective among the analyzed ones. So we will use it as an example to find out the reasons of market inefficiency and to provide some recommendations on improving the market efficiency.

Low efficiency of Ukrainian financial market decreases investment attractiveness of Ukraine. As a result it has insufficient financing, bad credit ratings and low positions in different international rankings. For example Index of Economic Freedom (by Heritage Foundation) published in 2013 put Ukraine on the 161-st place among 185 countries. The reasons were: restrictions for investment activity, undeveloped financial sector and unsatisfied state regulation. Another example is Global Competitiveness index (by World Economic Forum): Ukraine takes 84-th place among 152 countries. The main factors of low competitiveness are poor institution infrastructure, opacity and problems with access to financial resources (see The Global Competitiveness Report 2013–2014 for details).

Among other factors that should be mentioned is distorted structure of Ukrainian stock market: OTC-part is 10 times bigger than the organized one.

The result of these and other facts concerned Ukraine is inefficient financial market with the following list of properties:

- Financial market of Ukraine is small, unformed and is under construction;
- It is high volatility and risky;
- It has unconsolidated infrastructure;
- Unformed institutes of depositary and clearing activity, absence of market-makers and other element of infrastructure;
- The list of financial instruments is quite limited; some of common financial operations are prohibited by regulators.

We were trying to classify the main problems of Ukrainian financial market (see Fig. 6) in order to find out the reasons of inefficiency and to propose some concrete steps to solve them and thus to improve its efficiency.

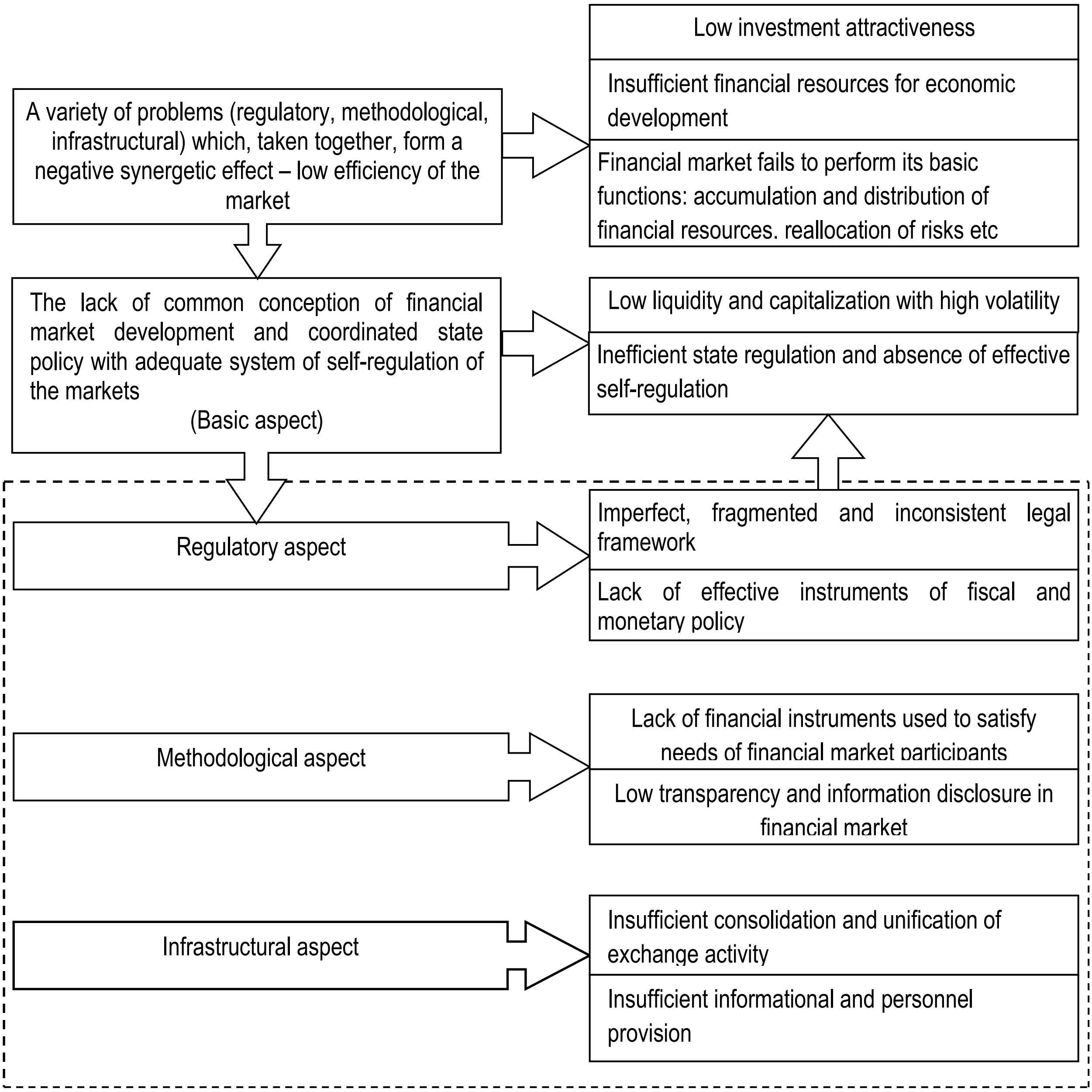

Fig. 6 – The main problems of Ukrainian financial market

We provide a list of actions directed on solution of the main problems of Ukrainian financial market (see Table 4).Their solution should improve the efficiency of financial market.

Table 4: Basic, regulatory, infrastructural and methodological aspects of improving the efficiency of Ukrainian financial market [own vision]

Directions of efficiency improving		Actions
Basic	Increased capitalization, liquidity and investment attractiveness of the financial market	Formation of favorable conditions for IPO's of Ukrainian corporations in Ukraine
		Stimulation of joint investment funds development including tax privileges
		Mitigation of issue, registration, and placement conditions of debt and equity securities
		Activation of private investors activity by increasing the financial literacy
		Formation of a favorable investment climate for foreign investors in the financial market of Ukraine
	Proper supervision and regulation of investment processes in the financial market	Harmonization of national legislation with international standards and implementation of rules and regulations in real economic life.
		Strengthening the SEC opportunities to influence the participants of financial market
		Coordination of activity between different state authorities which regulate activity on financial market
	Promotion of self-regulation in the financial market and proper protection of investors	Creation of the system of public and private protection of investors
Regulatory	Fiscal and monetary policy targeted on stimulation financial market development	Removal of legal collisions and fragmentation of the legal framework of the financial market of Ukraine, taking into account best international practices
		Implementation of unified approaches to taxation of income from investment activity
		Facilitation of the taxation of securities in terms of the double taxation of investment income of non-residents, the taxation of dividends, the rule of "30 days", etc.
		Facilitation of foreign exchange activity and active introduction of foreign exchange derivatives
Infrastructural	Improving market infrastructure and promotion of safe functioning (including depository, clearing, information systems and staffing)	Unified requirements for all exchange activity
		Implementation of modern models of trading: the DVP principle, centralized counterparty institute, uniform system of depository services in stock market, etc
		Internet-trading development as an instrument of individual investors resources obtaining, and tool of introduction of modern information technology and electronic document management among market participants
		Improving the quality of professional education among financial market participants
Methodological	Implementation of financial engineering products to expand the number of financial instruments	Provide a sufficient number of financial instruments with various combinations of risk, liquidity and profitability parameters and adapted to the needs of consumers of financial products
		Provide the institutional framework to the derivatives market development
	Improving transparency and disclosure in financial market based on generally accepted international financial reporting standards considering the best practice of corporate reports	Improving the quality of disclosure in the financial market by its participants, ensuring accuracy, completeness and timeliness of information on the basis of generally accepted IFRS
		Creation and maintenance of the actual functioning of the integrated state system of financial disclosure by issuers and other participants of financial market
		Efficient system of control on transparency of activity in financial market
		Regulation of credit-rating agencies activity, provision transparency of rating procedure

6. Conclusions

In response to the deepening impact of the crisis on the financial markets the issues explaining the behavior of the markets in general and the early prediction of a crisis for them in particular have become relevant. In the context of the search for alternative concepts of financial markets, as opposition to the EMH in the post-crisis period, the FMH becomes popular; it has got new categories and uses property of their long-term memory – so-called persistency to model the behavior of market indicators. A key indicator for its evaluation is the Hurst exponent with the R/S analysis as the highest priority calculation method.

Interpretation of the Hurst exponent for the world's developed and developing stock and foreign exchange markets led to the conclusion about the effectiveness of the implementation of the hypothesis for developed markets and FMH for developing markets in the pre-crisis period. Moreover, our calculations confirm the FMH during the crisis period for all the analyzed markets and indicators.

The results of the research substantiate the use of FMH as a basis for modeling the behavior of the financial market as well as the Hurst exponent to predict the direction of its development, has practical application both at the micro level (by the individual market participants), and macro-level (its regulators).

Based on results of research, using Ukraine as a country with extremely low level of market efficiency, we provide some recommendations on market efficiency increase. To do this we analyze the main problems of Ukrainian financial market and propose basic approaches to their solution.

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Appendix A

Methodology of Hurst exponent calculation (artificially generated data)

Author	Type of analysis	Results
Taqqu et al., (1995)	R/S, DFA	R/S overestimates the true Hurst exponent while DFA underestimates it.
Weron, R. (2002)	R/S, DFA	DFA outperforms R/S
Kantelhardt et al., (2002)	MF -DFA	Estimates based on (Anis and Lloyd, 1976) are better than the ones of (Peters,1994).
Couillard and Davison, (2005)	R/S analysis	No long-term memory in some financial returns, suggesting that Brownian motion cannot be rejected as a model for price dynamics
Grech and Mazur, (2005)	DFA, DMA	DFA outperforms DMA
V.Teverovsky, M. Taqqu, W.Willinger(1999)	R/S	Uncover a number of serious drawbacks to using Lo's method in practice.
Lo (1991)	R/S (modified)	Provide the test for long-range dependence. Lo reported that the rescaled range analysis could confuse long-term memory with the effects of short term memory. Results consistent with the EMH

- rescaled range analysis (R/S),
- generalized Hurst exponent approach (GHE),
- detrended moving average (DMA)
- detrended fluctuation analysis (DFA)
- multifractal generalization (MF-DFA)

Appendix B
Methodology of Hurst exponent calculation (financial data)

Author	Type of analysis	Object of analysis (time period)	Results
Barunik, Jozef&Kristoufek, Ladislav, 2010	R/S, GHE, DMA, DFA, MF-DFA	S&P 500 index (1983-2009)	Rescaled range analysis (R=S) together with generalized Hurst exponent approach (GHE) are robust to heavy tails in the underlying process. MF- DFA methods as well as DMA are not appropriate for data with heavier tails and small sample size. GHE methods proved to be very useful as they show the best properties.
Hja Su, LinYang (2003)	R/S	Shanghai and Shenzhen Stock Exchanges (1991-2001)	The changes of indices and stocks in the last period have positive impact in the next period in the short run, but this impact disappears for long time. The Hurst exponents of the weekly indices of Shanghai were around 0.60 and the Hurst exponents of the weekly indices of Shenzhen were in the range of 0.65 to 0.75.
Greene and Fielitz (1977)	R/S	Securities listed on the New York Stock Exchange	Claimed to have found significant evidence for the presence of long-range dependence.
Peters, 1991 and Peters, 1994	R/S	Monthly returns on the S&P 500 from January 1950 to July 1988	Estimates the Hurst exponent to be 0.778 for monthly returns on the S&P 500 from January 1950 to July 1988 Peters (1994) introduces the Fractal Markets Hypothesis (FMH).
Corazza and Malliaris (2002).	R/S	FOREX (1972-1994)	Foreign currency markets exhibit a H that is statistically different from 0.5. H is not fixed but it changes dynamically over time.
Glenn (2007)	R/S	NASDAQ	H of 0.59 was calculated for 1-day returns on the NASDAQ. H increased monotonically to a value of 0.87 for 250-day (annual) returns.
Lento, Camillo (2009)	R/S	DJIA (1998-2008)	Tests provide evidence that the H is able to identify long-term dependencies and anti-dependence.
Onali, Enrico and Goddard, John (2010)	R/S	Mibtel (Italy) and the PX-Glob (Czech Republic).	Find evidence of long-range dependence in the log return series.
Serletis and Rosenberg (2009)	R/S	US stock market indices	Fail to find evidence of long-range dependence for four US stock market indices.
Batten, Elli, and Fetherston (2003)	R/S	Nikkei stock index daily data (1980 -2000)	The null hypothesis of no long-term dependence is accepted for the whole sample and every sub-period using the modified rescaled range test, but not using the classical rescaled adjusted range test.
Berg, Lennart and Lyhagen, Johan (1996)	R/S	Swedish stock returns monthly data (1919-1995), weekly and daily data (1980-1995)	Hardly found any evidence of long run dependence. Using three different tests that are robust to short term dependence found that the modified R/S (rescaled range) test and ARFIMA-GARCH tests provide no support for long run memory in Swedish stock returns
Lo (1991)	R/S (modified)	US stock market (1872-1986)	Cannot find the long-term dependence
Ding et al. (1993)	R/S	S&P 500	Found considerable evidence of long memory in the squared returns
Jacobsen, Ben (1995)	R/S	Indices of five European countries, USA and Japan	Rejects the conclusion of long term dependence in these series.
Barkoulas, Labys, and Onochie (1997)	R/S	Futures	Claim to have found persistent long memory in a significant group of future contracts
NunoCrato, Bonnie Ray (1999)	R/S	Commodities (1977-1997)	Find no evidence for persistent behavior in futures' returns. Find overwhelming evidence of long memory behavior for the volatility of futures' returns.